THE PROBABILITY OF SWF OCCURRENCE IN RELATION TO SOLAR ACTIVITY

L.P.Morozova

Institute of Applied Geophysics, Goscomhydromet, USSR

Solar terrestrial researches have revealed substantial meaning of nonsteady events on the Sun, mainly solar flares, for the processes taking place in ionosphere. Solar flares result in the numerous consequences, account and prediction of which become necessary in our days. It is well known, that ionospheric disturbances following solar flares cause strong disturbances in the ionosphere, which severely violate radio-systems (communication, navigation, etc.). In the given paper we consider possibilities of sudden short wave fadeouts (SWF) prediction.

It was long ago when solar physicists came to the conclusion that solar flares are not the exclusive events of solar activity, but represent a natural phenomenon in the active regions development (RUST, 1976).

Thus, SID effects, evoked by the sudden increase of X-radiation in the range of 1-8 A during the flares, may not be considered as the single phenomena, but as a flow of casual events. So the long-term prediction of SWF effects occurrence probability may be based on the probability characteristics analysis of their occurrence on different phases of solar activity for a particular time interval. At the same time, it is assumed that a slow changing of statistic model parameters in the solar activity cycle takes place.

For solving the problem there were obtained and analyzed hystograms of SWF occurrence frequency distribution for one particular day using data on their registration within the World network of SID monitoring stations for the period of 1974-1985, published in "SOLAR GEOPHYSICAL DATA" (1967-1985).

Observation data were processed separately for various phases of solar activity. Thus, the results of 1974, 1975 and 1985 characterized solar activity minimum, results of 1976 and 1977 - growth phase, results of 1978-1980 - solar activity maximum, results of 1972, 1973 and 1984 characterized falloff phase of solar activity.

Figure 1 gives an example of the experimental data in the form of hystograms of n events probability distribution (n varies from 0 to 10) on a day for solar activity maximum or for solar activity minimum. Hystograms for all solar cycle phases are similar. They have maximum at n=0 with a different maximum value for various cycle phases of solar activity. The greatest number of days without SWF effects (i.e.=0) is typical for solar activity minimum; for this period P(0)=0.81. For the period of solar activity maximum this value is the least P(0)=0.37. Average value of SWF occurrence frequency on a day of solar activity minimum is n=0.45 but at solar activity maximum n=1.7.

Occurrence of SWF effects may be considered as a rare casual event. So it was quite natural to use Poisson distribution for theoretical description of occurrence frequency. After comparison a great difference between theoretical and experimental distributions was revealed. We may assume than SWF effects are rare casual events but separate effects are not independent. Flare activity on the Sun, leading to SWF occurrence in ionosphere, is a complex multiparametric process, depending upon spatial distribution of active regions on the solar disk, upon magnetic fields of these regions and upon many other parameters. Thus, it is evident that a model of independent occurrence (Poisson model) is not adequate to real conditions of SWF occurrence.

Experimental hystograms analysis allows to suggest that exponential distribution may be chosen as most suitable simplified distribution for their description. Satisfactory approximation with empiric distributions has been obtained with the help of superposition of two exponents.

Approximation expression was obtained for every phase of solar cycle, and besides coefficients were chosen empirically, basing on the experimental hystograms.

Solar activity minimum:

$$P(n) = 0.76*\exp(-2.7n) + 0.1*\exp(-0.54n) \qquad (1)$$

Solar activity maximum:

$$P(n) = 0.14*\exp(-0.26n) + 0.23*\exp(-0.86n) \qquad (2)$$

Increase phase of solar activity:

$$P(n) = 0.67*\exp(-2.6n) + 0.11*\exp(-0.51n) \qquad (3)$$

Falloff phase of solar activity:

$$P(n) = 0.46*\exp(-2.6n) + 0.17*\exp(-0.41n) \qquad (4)$$

Thus, approximate analytical expression for SWF occurrence frequency distribution may be presented in general as follows:

$$P(n) = A1*\exp(-\alpha 1n) + A2*\exp(-\alpha 2n) \qquad (5)$$

where coefficients A1, A2, $\alpha 1$ and $\alpha 2$ vary with a change of solar activity. On this base we assume that there may be link between parameters of approximate expression (5) and solar activity index, for example, relative sunspot number R_z or so-called Wolf number.

Fig.2 shows variation of parameters values A1, A2, $\alpha 1$, $\alpha 2$ and R_z during 21-st cycle of solar activity. It should be mentioned that approximate expression parameters are changing in the cycle with periodicity, typical for R_z variations.

So it is possible to express the coefficients of analytical expression (5) as a function of sunspot number:

$$A1 = A10 - \Delta A1(t)*y,$$

$$\alpha 1 = \alpha 10 - \Delta\alpha 1(t)*y,$$

$$A2 = A20 + \Delta A2(t)*y, \qquad (6)$$

$$\alpha 2 = \alpha 20 + \Delta\alpha 2(t)*y$$

where

$$y = R_Z - (R_Z)min/(R_Z)max - (R_Z)min \qquad (7)$$

It should be mentioned that in formulae (6) the values of A_{i0}, α_{i0} and $\Delta A1$, $\Delta\alpha 1$ for fixed phase of solar activity cycle remain constant, being obtained on the base of assembly average for every period.

Link of approximate expression parameters with Wolf numbers is determined by expressions (6). And it is known that nowadays sunspots are the most precisely predictable values, characterizing solar activity (VITINSKIY, 1963).

Using the prediction of R_Z values (Solar Geophysical Data, 1976-1985) of expressions (6) we obtain parameters of approximate analytical expression (5) that allow further to calculate n SWF effects occurrence probability on day for a given period beforehand, that is to realize long-term prediction. It is possible as well to give forecasting of expectable average number of SWF effects in the period of interest.

Results of control predictions have shown that statistical model is satisfactory describing empirical distribution of SWF effects occurrence for various phases of solar activity, or gives the assessment of average number of effects for a particular period, for example, a year in advance. The results of long-term prediction by average values are statistically only slightly different from monitoring results.

Thus, our work has shown that the possibility of long-term prediction of SWF effects occurrence frequency is conditioned by slow temporal variations of statistic model parameters and by link of these parameters with sunspot number as well.

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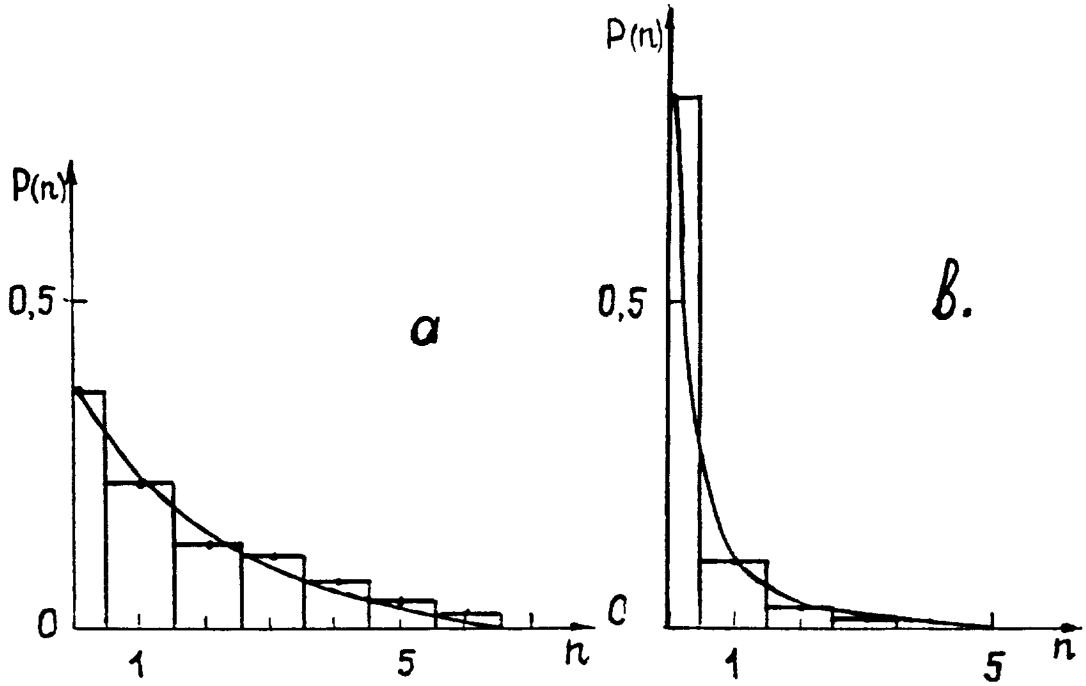

Fig. 1. Distribution hystograms of SWF effects occurrence probability in one day: a) solar activity maximum; b) solar activity minimum.

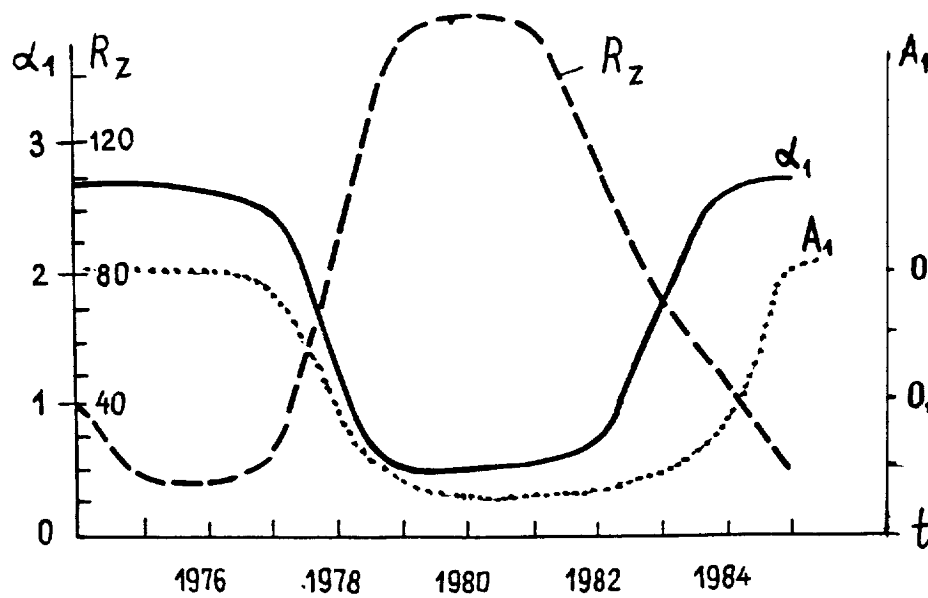

Fig.2.Variation of statistical model coefficients and sunspot number for the period of 1974-1985.